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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): TAKAHASHI, et al.

Serial No.: 09/414,520

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For: PLASMA PROCESSING APPARATUS AND A PLASMA PROCESSING METHOD

Group: 1763

Examiner: Zervigon, R.

#24
5/22/03
MW

BRIEF ON APPEAL

Assistant Commissioner for Patents
Washington, D.C. 20231

May 19, 2003

Sir:

This appeal brief is respectfully submitted in connection with the above-identified application in response to the Final Office Action dated September 19, 2002, and the Advisory Action dated January 6, 2003 rejecting claims 1 - 2, 4 - 7, 9 and 10.

(1) REAL PARTY IN INTEREST

The real party in interest is Hitachi, Ltd. of Japan.

(2) RELATED APPEALS AND INTERFERENCES

There are no related appeals and interferences.

(3) STATUS OF CLAIMS

Claims 3 and 8 have been canceled.

Claims 1, 2, 4 - 7, 9 and 10 are pending in this application and are the subject matter of this appeal.

(4) STATUS OF AMENDMENTS

No amendments to the claims were presented subsequent to the final Office Action of September 19, 2002.

(5) SUMMARY OF INVENTION

The invention relates to a plasma processing apparatus (Claims 1, 2, 4 and 5) and method (Claims 6, 7, 9 and 10) for etching an insulation film using a gas containing gas species that contain fluorine and carbon. Referring to Figure 1, the plasma processing apparatus includes a vacuum processing chamber 1, a sample table for mounting a sample 10 which is processed in the vacuum processing chamber, and a plasma generation means comprising an electron cyclotron resonance system in which a microwave is provided having a frequency of from 300 MHz to 1 GHz and which generates a plasma in which the degree of plasma dissociation is an intermediate degree (in Figure 1, and as described on page 13, lines 4 - 14, the plasma generation means is represented by at least a coil 2, disc-shaped antenna 5, power supply 6, induction shaft 7, dielectric body 8 and electrode 9). The temperature of the inner wall of the chamber is controlled by a wall 12 containing a coolant medium, as described on page 14, lines 16 - 27. The temperature of the region

that forms a side wall of the vacuum processing chamber is controlled to have a range of 10 °C to 120 °C.

Features of the claimed invention include that the degree of plasma dissociation is a middle or intermediate degree (that is, a relatively high level of CF_2, and CF compared to the amount of F) and that a side wall of the vacuum processing chamber is controlled to have a range of 10 °C to 120 °C. (See, for example page 10, line 18 to page 11, line 7.) As explained more fully in the specification, for example, on pages 2 - 3, a middle or intermediate degree of dissociation is desirable for etching silicon oxide. As explained more fully in the specification, for example on pages 9 - 11, the low temperature of 10 °C to 120 °C for a side wall of the vacuum processing chamber serves to limit the amount of gas discharge from reaction products that become deposited on the side wall. The range of 10 °C to 120 °C is selected as being significantly lower that the desorption temperature of the reaction products. The amount of gas discharge from the surface of the side wall remains limited and stable even when there are temperature fluctuations of ± 10 °C, thereby providing more stable deposition conditions.

Accordingly, Claim 1 is directed to a plasma processing apparatus for etching an electrically insulating film, the plasma processing apparatus having a vacuum processing chamber, a sample table for mounting a sample which is processed in said vacuum processing chamber, and a plasma generation means, wherein a plasma processing is carried out by generating a plasma in response to introduction of a gas which contains at least carbon and fluorine, and a gas species is generated which contains carbon and fluorine according

to a plasma dissociation. In particular, the plasma processing apparatus comprises plasma generation means comprising an electron cyclotron resonance system in which a microwave is provided having a frequency of from 300 MHz to 1 GHz and which generates a plasma in which the degree of plasma dissociation is an intermediate degree, so that a gas species containing carbon and fluorine is generated fully in the plasma, and a temperature of a region which forms a side wall of said vacuum processing chamber is controlled to have a range of 10 °C to 120 °C and wherein the sample for etching by the plasma is an insulating film.

The invention of claim 2 further defines the plasma generation means as a source of plasma in which an electron energy is in a range of from 0.25 eV to 1 eV

The invention of claim 4 further defines that in the plasma generation means, a drive of a plasma exciting power supply is carried out intermittently.

The invention of claim 5 further defines the means for adjusting a temperature of the vacuum wall as being by a temperature adjusted coolant medium.

The invention of claim 6 is directed to a plasma processing method using a vacuum processing chamber, a sample table for mounting a sample which is processed in said vacuum processing chamber wherein the sample is an electrically insulating film, and a plasma generation means, wherein a plasma processing is carried out by generating a plasma in response to introduction of a gas which contains at least carbon and fluorine, and a gas species is generated which contains a carbon and fluorine according to a

plasma dissociation. The plasma processing method comprises the steps of generating a plasma, wherein the plasma generation is effected using an electron cyclotron resonance system in which a microwave having a frequency of from 300 MHz to 1 GHz is employed and wherein a degree of plasma dissociation is an intermediate degree and said gas species containing carbon and fluorine is generated fully in the plasma, and controlling a temperature of a region which forms a side wall of said vacuum processing chamber to have a range of 10 °C to 120 °C.

The invention of claim 7 further defines the method to provide that the plasma generation produces a plasma in which an electron energy is a range of from 0.25 eV to 1 eV

The invention of claim 9 further defines the method to provide that in said plasma generation, a drive of a plasma exiting power supply is carried out intermittently.

The invention of claim 10 further defines the method to provide that in controlling the temperature of the vacuum wall, a temperature adjusted coolant medium is used.

(6) ISSUES

(1) Whether Claims 1, 2 and 5 were properly rejected under 35 U.S.C. §103(a) as obvious over Satou in view of Ovshinsky et al.

(2) Whether Claims 4, 6, 7, 9 and 10 were properly rejected under 35 U.S.C. §103(a) as obvious over Satou in view of Ovshinsky and further in view of Akahori.

(7) GROUPING OF CLAIMS

Appellants consider all the claims in the application to be separately patentable, and thus the claims do not stand or fall together.

(8) ARGUMENTS

(1) Whether Claims 1, 2 and 5 were properly rejected under 35 U.S.C. §103(a) as obvious over Satou in view of Ovshinsky et al.

Claims 1, 2,and 5 were rejected under 35 U.S.C. §103 as obvious over Satou et al (U.S. Patent No. 5,961,850) in view of Ovshinsky et al (U.S. Patent No. 5,324,553). The Examiner alleged that Satou et al teaches various limitations of the claimed invention, as listed in items i. through viii. on pages 2 - 3 of the Office Action of September 19, 2002. The Examiner acknowledged that Satou et al does not teach (ix.) a gas that contains at least carbon and fluorine wherein a gas species is generated which contains carbon and fluorine according to a plasma dissociation, and (x.) plasma generation means which generates a plasma in which the degree of plasma dissociation is a "middle" degree and the gas species containing carbon and fluorine is generated fully in the plasma. The Examiner alleged that Ovshinsky teaches a similar plasma ECR processing apparatus, a microwave frequency in the 300 MHZ to 1 GHz range, a plasma generation means in which the degree of plasma dissociation is a "middle" degree and average electron energies around 2 eV. The Examiner alleged that because Ovshinshky discusses average electron energies, it would be expected that electron energy values less than the average would be

expected to fall within the range of 0.25 eV to 1 eV. The Examiner took the position that it would be obvious to implement Ovshinsky's microfrequency range and plasma middle degree of dissociation as operating conditions for Satou's plasma ECR processing apparatus. The Examiner alleged that motivation for implementing Ovshinsky's microfrequency range and plasma middle degree of dissociation as operating conditions for Satou's plasma ECR processing apparatus would be drawn from Ovshinsky's benefit of resonating different atomic components present in the plasma including higher energy transfers to neutrals resulting from a larger ratio of resonating ions.

It is respectfully submitted that this rejection is in error. As discussed above, the present invention is directed to a plasma processing apparatus for etching and method for plasma processing using a gas containing gas species that contain fluorine and carbon. Features that distinguish the present invention from the methods described in the cited references include that the degree of plasma dissociation is a middle or intermediate degree (that is, a relatively high level of CF_2, and CF compared to the amount of F). As explained more fully in the specification, for example, on pages 2 - 3, a middle or intermediate degree of dissociation is desirable for etching silicon oxide. These features are neither disclosed nor suggested by the cited references. In particular, Satou et al does not disclose processing with gas species containing carbon and fluorine. There is no teaching or suggestion in Satou et al of an apparatus for controlling the extent of dissociation of a processing gas or for using a plasma excitation frequency of 300 MHz to 1 GHz.

not claimed in meth.

Moreover, Ovshinsky does not supply the elements missing from Satou

et al. Ovshinsky relates to a method for the improved microwave deposition of thin films. That is, the invention described in the reference does not relate to a plasma etching apparatus as in the present invention but rather, relates to methods and apparatus for plasma deposition of film (for example, CVD). Plasma etching is completely different from plasma deposition of film, since etching removes thin films, whereas film deposition grows deposits on a wafer. Accordingly, the apparatus constitution, the method of using the apparatus and the process conditions are naturally different from each other, and teachings in one art do not translate to the other art. Accordingly, Ovshinsky is not properly combinable with Satoh.

Further, the Examiner is in error in asserting that Ovshinsky teaches the frequency of microwaves in the range of 300 MHz to 1 GHz in any process or apparatus relevant to the present invention. The mention in the reference of 915 MHz is only with respect to use in PECVD (Plasma Enhanced Chemical Vapor Deposition) and not in an etching method or apparatus.

Moreover, the Examiner is in error in alleging that Ovshinsky describes that dissociation is at an intermediate degree. Ovshinsky merely describes that the average energy of electrons is 2 eV, they constitute a Maxwell-Boltzmann distribution and the degree of ionization is extremely low at a pressure of 0.5 - 1.0 Torr. Dissociation and ionization are different. While dissociation includes various processes, the term refers to the process by which electrons under ECR acceleration by microwaves waves collide against molecules to decompose them (for example CF_4 is decomposed into F and CF_3), in which the energy is determined on every dissociation reaction and does not change

depending on the pressure. Further, in a plasma at an average electron energy of 2 eV, there is the problem that the dissociation proceeds excessively (for example, CF_4 is decomposed into CF or F, and the amount or CF_2 or CF_3 is decreased). Therefore, it is important to have a lower average electron energy in an etching apparatus and method. The mere presence of electrons at 0.25 - 1 eV is not effective if the average electron energy of the plasma is 2eV. Further, the electron energy is that accepted by electrons when they are accelerated at a frequency of ECR, which corresponds to the frequency of microwaves.

The Examiner alleged that Ovshinsky describes the dissociation at an intermediate degree in column 10, lines 3 - 6 and column 10, lines 35 - 65. However, this passage merely describes that the feature of microwave ECR resides in the high degree of ionization. Dissociation is not mentioned.

While the Examiner alleged that Ovshinsky also discusses ionization, it must be understood that the ionization and the dissociation are different. Dissociation proceeds in the presence of electrons at high energy, whereas ionization proceeds when the density of electrons is high (electron having energy higher than the ionization energy: which is lower than the dissociation energy). If the density of electrons at high energy is higher, both the dissociation and ionization proceed naturally. However, what Ovshinsky describes is that ionization proceeds because the electron density is high in ECR (this has a same meaning as high plasma density, which is described in column 10, line 60)

The Examiner also mentioned the cyclotron resonance of ions but the

Is claimed

present invention does not utilize the cyclotron resonation of ions. What accelerates the ions is a high frequency bias applied to a wafer boat, and cyclotron resonation is not utilized.

Accordingly, Ovshinsky does not provide relevant teachings or suggestions for modifying the apparatus and method of Satou to meet the limitations of the present invention.

Accordingly, Claims 1, 2, and 5 would not have been obvious over Satou et al or Ovshinsky, alone or in combination. It is respectfully requested that the rejection of Claims 1, 2,and 5 under 35 U.S.C. §103 as obvious over Satou et al (U.S. Patent No. 5,961,850) in view of Ovshinsky et al (U.S. Patent No. 5,324,553) be reversed.

(2) Whether Claims 4, 6, 7, 9 and 10 were properly rejected under 35 U.S.C. §103(a) as obvious over Satou in view of Ovshinsky and further in view of Akahori.

Claims 4, 6, 7, 9 and 10 were rejected under 35 U.S.C. §103(a) as obvious over Satou et al (U.S. Patent No. 5,961,850) in view of Ovshinsky (U.S. Patent No. 5,324,553) and further in view of Akahori et al (U.S. Patent No. 6,215,087). Satou and Ovshinsky were applied as discussed above, and Akahori was applied as allegedly teaching intermittent microwave application. The Examiner took the position that it would have been obvious for Satou or Ovshinsky to implement the Akahori intermittent microwave application.

It is respectfully submitted that this rejection is in error.. The differences between the present invention and the teachings of Satou and Ovshinsky are

as discussed above. As with Ovshinsky, Akahori relates to plasma film forming methods and apparatus and not to etching methods and apparatus for etching with a carbon and fluorine-containing gas. (Although the reference mentions etching, this is in connection with O_2 gas used to round out shoulders as part of an embedding process.) In particular, film forming on a wafer involves deposition of particles of large deposition probability or particles for film deposition, and such particles must be suppressed in etching, since they interfere with the etching process. Accordingly, the teachings of Akahori are not relevant to the present invention. For example, the teachings of Akahori of modulating microwaves into pulse-like form (pulsed microwaves) is for the purpose of increasing electron temperature, thereby increasing radicals at high energy and increasing deposition speed, whereas in the present invention, in the context of etching, the use of intermittent microwaves is to control dissociation and improve etching performance by lowering the electron temperature.

Accordingly, Claims 4, 6, 7, 9 and 10 would not have been obvious over Satou, Ovshinsky, or Akahori, alone or in combination. It is respectfully requested that the rejection of Claims 4, 6, 7, 9 and 10 under 35 U.S.C. §103 as obvious over Satou et al (U.S. Patent No. 5,961,850) in view of Ovshinsky (U.S. Patent No. 5,324,553) and further in view of Akahori et al (U.S. Patent No. 6,215,087) be reversed.

(9) CONCLUSION

For the foregoing reasons, appellants respectfully submit that the Examiner's final rejection of the claims is improper and without basis, and it is respectfully requested that the Honorable Board of Patent Appeals and Interferences reverse the Examiner's final rejection.

A copy of the claims on appeal, i.e. claims 1, 2, 4 - 7 and 9 - 10, is found in the attached Appendix.

A check in the amount of $320.00 to cover the fee for filing this Brief on Appeal is attached.

Kindly charge any additional fees due, or credit overpayment of fees, to Deposit Account No. 01-2135. (File No. 520.37698CX1).

Respectfully submitted,

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APPENDIX

1. (four times amended) In a plasma processing apparatus for etching an electrically insulating film, the plasma processing apparatus having a vacuum processing chamber, a sample table for mounting a sample which is processed in said vacuum processing chamber, and a plasma generation means, wherein a plasma processing is carried out by generating a plasma in response to introduction of a gas which contains at least carbon and fluorine, and a gas species is generated which contains carbon and fluorine according to a plasma dissociation, the plasma processing apparatus comprising:

plasma generation means comprising an electron cyclotron resonance system in which a microwave is provided having a frequency of from 300 MHz to 1 GHz and which generates a plasma in which the degree of plasma dissociation is an intermediate degree and said gas species containing carbon and fluorine is generated fully in the plasma, and a temperature of a region which forms a side wall of said vacuum processing chamber is controlled to have a range of 10 °C to 120 °C and wherein the sample for etching by the plasma is an insulating film.

2. (twice amended) A plasma processing apparatus according to Claim 1, wherein

said plasma generation means is a source of plasma in which an electron energy is in a range of from 0.25 eV to 1 eV.

4. (amended) A plasma processing apparatus according to claim 1, wherein

in said plasma generation means, a drive of a plasma exciting power supply is carried out intermittently.

5. (amended) A plasma processing apparatus according to any one of Claim 1, Claim 2 or Claim 4, wherein

as a means for adjusting a temperature of said vacuum wall, a temperature adjusted coolant medium is used.

6. (four times amended) In a plasma processing method using a vacuum processing chamber, a sample table for mounting a sample which is processed in said vacuum processing chamber wherein the sample is an electrically insulating film, and a plasma generation means, wherein a plasma processing is carried out by generating a plasma in response to introduction of a gas which contains at least carbon and fluorine, and a gas species is generated which contains a carbon and fluorine according to a plasma dissociation, the plasma processing method comprising the steps of:

generating a plasma, wherein said plasma generation is effected using an electron cyclotron resonance system in which a microwave having a frequency of from 300 MHz to 1 GHz is employed and wherein a degree of plasma dissociation is an intermediate degree and said gas species containing carbon and fluorine is generated fully in the plasma, and controlling a temperature of a region which forms a side wall of said vacuum processing chamber to have a range of 10 °C to 120 °C.

7. (twice amended) A plasma processing method according to claim 6, wherein

said plasma generation produces a plasma in which an electron energy is a range of from 0.25 eV to 1 eV.

9. (twice amended) A plasma processing method according to claim 6, wherein

in said plasma generation, a drive of a plasma exiting power supply is carried out intermittently.

10. (amended) A plasma processing apparatus according to Claim 6, Claim 7 or Claim 9 wherein as a means for adjusting a temperature of said vacuum wall, a temperature adjusted coolant medium is used.